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**The Analysis of the Limitations Which Hinder Inquiry-based Learning and Students'
Creativity Development in Chinese Science Education**

By

Xiao Shao

A Major Research Paper
Submitted to the Faculty of Graduate Studies
through the Faculty of Education
in Partial Fulfillment of the Requirements for
the Degree of Master of Education
at the University of Windsor

Windsor, Ontario, Canada

2018

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**The Analysis of the Deficiencies Which Hinder Inquiry-based Learning and Students'
Creativity Development in Chinese Science Education**

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April 12, 2018

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ABSTRACT

It is believed that developing the creative thinking ability is the key to maintaining competitiveness in the automation age. Science education plays an important role in preparing the young generation's creativity to face the unpredictable future. Inquiry-based learning, which is a creativity promoting pedagogy, has been presented as the major teaching strategy in China. However, several deficiencies of Chinese science education still limit the utilization of inquiry-based learning and students' creativity development. This paper analyzes the combination of creativity development and science education in China through the vision of inquiry-based learning. The purpose of this paper is to emphasize the importance of students' creativity ability training and demonstrate the limitations of science education in China. Further, the paper provides several recommendations in nurturing Chinese students' creativity in science learning.

Keywords: Science education, Chinese science education, Inquiry-based learning, Creativity, Creative thinking ability

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CHAPTER I: INTRODUCTION

Background Information

Education plays an important role in developing students' creativity. However, public education in China has been criticized as “stereotypes,” “spoon feeding,” “killing creativity,” and “knowledge acquisition” instead of “releasing creative potential” (Shaheen, 2010). Inquiry-based learning, as a creativity promoting pedagogy, has been emphasised in curriculum reform since 1999. In the government profile, it expressly presents that inquiry-based learning is the major pedagogy in Chinese science education (Dello-Iacovo, 2009). The government highlighted inquiry-based teaching in the curriculum reform, but it is the most difficult item in the reform. It requires student transformation from passive acceptor to active learner. In order to develop creative thinking abilities in science classes: query activities, exploration, and seeking differences should be included. Educators should promote open-ended questions and encourage students' curiosity (Zheng, 2002). Nevertheless, when conducting inquiry-based learning in practical classes, several conflicts between the “new pedagogy” and “traditional pedagogy” occur (Li, 2015).

It is important to develop students' creativity due to the artificial intelligence (AI)-driven economy and the transformation of the job market. A concern of whether human jobs can be replaced by robots has been discussed significantly (Chui, Manyika & Miremadi, 2016). A study of the financial services firm Cornerstone Capital Group

indicated that as many as 7.5 million retail jobs are at risk of automation in the next 10 years (McFarland, 2017). When comparing AI with humans, the most unique and significant difference is creative thinking ability. AI repeats operations and tasks, however, human intelligence is more diverse and broad (Kuilian, 2017). At the same time, creativity is a crucial skill to maintain employment, gain achievement, and increase competition in the future economy (Shaheen, 2010). A U.S. study, *Creativity and Education: Why it Matters*, indicated that creativity is not only a personality trait but also a skill that can be learned (Adobe, 2012). Lorenzo (2016) stated people who actually investigate new technologies may have a brighter future. Updating, creating and building smart machines will be a valuable capability for workers to remain employed. Thus, developing the skill of creativity will allow human intelligence's superiority to endure. The key for people to maintain competitiveness is improving the creative thinking ability.

However, Robinson believes that adults are squandering children's ability of innovation. The public education system and the hierarchy of subjects are limiting students' creativity by decreasing their "mistakes", eliminating children's talents by correcting their unusual behaviours, and trying to make every student a university professor (Robinson, 2006).

Passing on knowledge is not the unique purpose of education because the required knowledge for the future is unpredictable (Shaheen, 2010). In China, inquiry-based learning pedagogy has been emphasized to promote students' creativity and prepare the

young generation for the unpredictable future (Wan, Wong & Zhan, 2012). In addition, it is believed that the most suitable way to foster children's creativity is through science education. Education plays an important role in promoting students' creativity; at the same time, enhancing the knowledge and skills of science would benefit students' development in creative thinking (Tan & Lee, 2004).

Problem Statement

In terms of preparing individuals to survive in the age of popular science and new technology, the young generation should develop their ability of creativity, which is considered a "fundamental life skill" (Craft, 1999). Educational institutions are places where youth acquire knowledge of the world, and educators play an important role in encouraging children's natural quality of creativity (Feldman & Benjamin, 2006). Nurturing creativity in school facilitates students' creative qualities to face and solve problems in daily life, and develop their abilities for future success (Lin, 2011).

Inquiry-based learning as a creativity improving pedagogy has been emphasized in the curriculum reform since 1999 in China (Dello-Iacovo, 2009). This paper is going to analyze the combination of creativity development and science education in China through the vision of inquiry-based learning. The purpose of this paper is to emphasize the importance of students' creativity ability training and demonstrate the limitations of science education in China. Further, the paper provides several recommendations in nurturing Chinese students' creativity in science learning.

Although the reform of science curricula has been emphasized for a long time, Chinese education is still suffering the criticism of limiting students' creative thinking ability (Li, 2015). It is necessary to explore the reasons why Chinese science education did not gain the expected achievements, and to discover the limitations of practical implementation of inquiry-based learning.

Most of the existing literature focuses on either inquiry-based learning or creativity development. There are limited articles involving both. Besides, many articles include insufficient discussion of deficiencies and ignore several themes such as students' internal factors and the limitation of scientific experiment. Nevertheless, this paper emphasizes the importance of students' creativity development through practical implementation of inquiry-based learning and describes ten categories of related challenges.

The emphasis of the importance of students' creativity cultivation and the discovery of the limitations will benefit education administration, teaching and learning, and future research. Administrators can make adjustments to the education policy in China based on the reported deficiencies and hence will benefit teaching and learning in Chinese science classrooms. Educators will realize the existing problems and make improvements. In addition, it will draw more attention to Chinese science education. With the increasing amount of research, there will be more suggestions for improvement.

Research Questions:

1. Has Chinese science education gained the expected achievement by conducting inquiry-based learning?
2. What are the limitations that hinder inquiry-based learning and students' creativity development in Chinese science education?
3. What strategies can be used for Chinese science education to effectively improve inquiry-based learning and students' capability of creative thinking?

Definition

Inquiry-Based Teaching in Science Education

The sustainable development plan requires educators to cultivate students' ability in innovation; at the same time, inquiry-based teaching is considered as a constructivist pedagogical approach which offers opportunities for students to improve creativity capability (Chong, Chong, Shahrill & Abdullah, 2017). Inquiry-based teaching refers to teachers or instructors who start teaching scientific knowledge by posing questions and students develop scientific experiments to investigate these questions (Teaching Inquiry Science Activities). The major phases of inquiry-based teaching are: Engage, Explore, Explain, Elaborate, and Evaluate (5-E model) (Teaching Inquiry Science Activities). With the support of teachers or instructors, students in the 5-E model are required to think independently, and conduct scientific experiments independently or collaboratively.

In the process of inquiry-based activities, teachers encourage students to release their imaginations, extend ideas, and develop hypotheses. For example, when prompting a “big idea question” at the beginning of the class, the question should begin with “what” and “what if.” Instead of indicating the answer directly, teachers encourage brainstorming in the class and guide students to question and test their assumptions (Coffman, 2012). Inquiry-based learning offers students opportunities to discover knowledge by themselves (Longo, 2010). Students are allowed to discuss their own perspectives, reflect on the process of exploration, and explain their choices (Michalopoulou, 2014).

CHAPTER II: LITERATURE REVIEW

Literature Search Method

In order to collect information and answer the research questions, an exhaustive search was conducted. In the process of research, four strategies were utilized: a database search, a search terms strategy, selection criteria, and a hand search.

Database Search

The online databases were queried to identify relevant articles in Chinese science education, the implementation of inquiry-based learning, and students' creativity development. The databases included the University of Windsor's Leddy Library, Education Resources Information Center (ERIC), Google Scholar, and Ixueshu, which is a Chinese search engine.

Search Terms

The key concepts of the literature search are "Inquiry-based learning in Chinese science education," "limitations of teaching inquiry-based practical work" and "students' creativity development." Several keywords such as "inquiry-based learning," "Chinese science education," "limitations of Chinese science education," "inquiry-based practical work," and "creativity development" were utilized in the process of literature research. In order to reach more related articles, various synonyms were included. "Inquiry-based teaching" and "inquiry pedagogy" are similar to "inquiry-based learning." "Difficulties," "deficiencies," and "obstacles" are the synonyms for "limitations." "Practical

implementation” is the synonym for “practical work.” “Creativity” can be replaced by “creative thinking” and “innovation ability.” These keywords were input into the search engine along with the location of China to narrow the location scope to China only. All the keywords and synonyms were permuted and combined in the process of related literature searching.

Selection Criteria

Several criteria were selected for choosing relevant materials. All of the selected literature must meet the certain criteria. The article must focus on Chinese K-12 education; it must be published in the past 20 years; it must relate to the implementation of inquiry-based learning in Chinese classes; and it must reflect students’ creativity development. These criteria limited the research to 42 studies.

Hand Search

The reference lists of the selected literature were reviewed to find more related articles. The website of the Ministry of Education of the People’s Republic of China was visited to learn about the science education policies as well.

The selected literature relates to the goals of Chinese science education, the limitations of inquiry-based practical implementation and students’ creativity development. The limitations are categorized into ten themes: the influence of the score-orientated science education in China, the unified content and management, lacking equipment in classrooms and laboratories, teachers and students’ traditional beliefs,

teachers' authority in classroom, the isolated academic courses, the size of Chinese classrooms, the inadequateness of teachers' capabilities, the overload of teachers' work, as well as students' internal deficiencies.

The Expected Science Education

The Chinese government pays great attention to students' creativity development; several formal documents have been issued since 1998. Table 1 shows that creativity education policies are guiding the reform of education in China, and governments are making effort in the cultivation of students' creativity development (Hui & Lau, 2010). In 1999, the curriculum reform raised the issue that improving the quality of education in China, and the central goal of the reform is to promote students' creative and practical capabilities (Central Committee of the Communist Party of China & the State Council, 1999). The curriculum reform aimed at encouraging students' curiosity, increasing students' engagement in science experiments, providing more investigations in class, involving students in more collaborative activities, and improving students' inquiry and explorative abilities (Dello-Iacovo, 2009).

The government and Chinese families pay great attention to education, especially science education. The science education system is supported by the public. Science education aims at delivering basic scientific knowledge and fostering curiosity and enthusiasm among students (Ministry of Education of the People's Republic of China, 2017). In the meantime, students are expected to have the right attitude toward science

Table 1. The creativity education policy in mainland China, Hong Kong, and Taiwan

	Mainland China	Hong Kong	Taiwan
Year of issue	1998	2001	2002
Formal documents	21st Century Educational Reform and Higher Education Law	Learning to Learn: The Way Forward in Curriculum Development	White Paper on Creative Education: Establishing a Republic of Creativity for Taiwan
Keywords related to creativity	Technology, innovation, creativity, tertiary education & industry	Creativity, curriculum, generic skills, problem solving in elementary and secondary education	Creativity, individual, school, societal, industrial and cultural levels, implementing principles and strategies

(Hui & Lau, 2010, p. 217).

and its correlation with the social and natural environment (Ministry of Education of the People's Republic of China, 2017). In the government profile, it expressly presents that inquiry is the major pedagogy in science education. Students will have more opportunities to attend scientific practical activities. These activities should be authentic enough for students to connect knowledge to daily lives, and these activities should be conducted by students. Students obtain the ability of scientific inquiry from their personal experience of conducting practical activities. Thus, they can use the inquiry method for their further science learning and exploring science outside of the classroom.

Inquiry-Based Teaching Benefits Students' Thinking

Traditional lecture teaching of science can no longer meet the purpose of preparing students' creativity for the unpredictable future. As a representative pedagogy promoting scientific experiment, inquiry-based teaching was studied by several researchers for a better understanding of its effects on science learning. In order to break the “spoon feeding” stereotypes in traditional science class, students are required to acquire scientific knowledge through experiments (Shaheen, 2010). Based on this expectation, teachers allow students to discover scientific concepts as real scientists. Instead of passing on knowledge directly, teachers introduce scientific practice work for students to investigate and test their assumptions (Chong, Chong, Shahrill & Abdullah, 2017).

Şimşek and Kabapınar (2010) conducted a study in a private elementary school in Istanbul. They applied inquiry-based pedagogy in a fifth-grade science class lasting eight weeks. Students conducted experiments, observed and discussed their findings in a science laboratory. The researchers used three instruments: concept test, scientific process skill test, and scientific attitude scale, to evaluate students' scientific concepts acquisition, scientific process skill improvement, and scientific attitude alteration. In the inquiry-based classroom, students actively engaged in teaching activities; besides, their learning process was supported by guidance from instructors and scaffolding from classmates. Şimşek and Kabapınar's (2010) research proves that inquiry-based teaching improves students' internalization of scientific concepts and has a better enhancement of

students' scientific process skills. In addition, the process of engagement, exploration, explanation, and elaboration benefits students' development of critical thinking and creative thinking (Şimşek & Kabapınar, 2010).

Kitot, Ahmad, and Seman (2010) released their research article about the impact of inquiry teaching on students' critical and creative thinking. The three researchers designed a quasi-experiment over the treatment class and the control class. All the participants were randomly selected from science class, and they were given survey forms before and after teaching to compare the change of their critical thinking level. They collected data and demonstrated a significant difference between the treatment class and control class in terms of the change of students' critical thinking level before and after eight-weeks of the experiment. It appears that students in the treatment class who received inquiry teaching have a more obvious increase in their critical and creative thinking ability than those in the control class receiving their normal teaching processes. Kitot, Ahmad, and Seman (2010) encouraged teachers to implement inquiry teaching in classrooms so that students have more chances to procure high order thinking which will enhance critical and creative thinking. Apart from concepts learning, research skill acquisition, creativity, and critical thinking, inquiry-based learning also was proven to have effects on students' science literacy skills and self-confidence when facing challenges in practicing science (Gormally, Brickman, Hallar & Armstrong, 2009).

Challenges of Inquiry-based Teaching

Apart from all the research results proving inquiry-based teaching can improve students' learning outcomes, Kim and Tan (2011) considered the difficulties of practice inquiry teaching in the classroom. Science educators have been encouraged to conduct scientific practice work for their students; however, students still have low opportunities to practice their learning content. There are various factors such as time limitations and resource scarcity hindering the spread of practical work which is part of inquiry-based learning. In other words, inquiry-based pedagogy lacks supporting conditions in school teaching. Other than that, science teachers' content knowledge, attitude, and teaching abilities have influences on inquiry oriented pedagogy (Kim & Tan, 2011). The two researchers interviewed 38 third-year university students majoring in science teaching in Korea. These participants narrated their personal experiences in using practical works in the classroom and expressed their reflective feelings about their experience. Kim and Tan (2011) organized the aspects that encouraged and discouraged these students' implementation of practical teaching methods such as inquiry-based teaching. The results of their research were organized into several suggestions for science teachers. These suggestions include providing inquiry stimulated questions for students, balancing science practical work and teaching, and adapting inquiry-based teaching into the existing teaching environment (Kim & Tan, 2011).

Although it is reasonable that inquiry-based pedagogy would greatly benefit students, in practice, various schools in China did not gain the expected achievement (Li, 2015). When applying the curriculum reform in practice, educators reported the lack of financial support and implementation guidance. Most teachers continued their traditional teaching method. Even “inquiry-based activities” were textbook-oriented and followed the traditional beliefs. In addition, the reform gave suggestions for curriculum improvement; however, the evaluation system remains unchanged. The college entrance examination has not been influenced by the reform (Dello-Iacovo, 2009). At the same time, more than 70% of administrators believe that the Chinese evaluation system negatively affects the advancement of curriculum reform (Yu, et al., 2005).

When analyzing creativity, science, and science education, the Nobel Prize as the great and authoritative honour in the science field cannot be ignored (Tan, 2001). The Nobel Prize has been awarding laureates’ contribution in physics, chemistry, physiology or medicine, literature, and peace by the Royal Swedish Academy of Sciences since 1901 (Nobel Media AB, 2018). When looking at the award history, the Nobel Prize in physics, chemistry, and physiology or medicine reflect the science research and science education in a country. However, there are rare Chinese Noble laureates and even fewer laureates in the science field.

According to table 2, there are only five laureates in the science area who were born in China. At the same time, four of them were awarded the Nobel Prize after studying

Table 2: Nobel Laureates in science who were born in China

Nobel Laureates in science who were born in China				
Name	Year of winning	Field	Education Background	Detail of Achievements
Chen Ning Yang	1957	Physics	University of Chicago in January 1946	"for their penetrating investigation of the so-called parity laws which has led to important discoveries regarding the elementary particles"
Tsung-Dao Lee	1957	Physics	University of Chicago from 1946 to 1950	"for their penetrating investigation of the so-called parity laws which has led to important discoveries regarding the elementary particles"
Daniel C. Tsui	1998	Physics	Hongkong Augustana College in 1958; 1967 got Ph.D. at the University of Chicago	"for their discovery of a new form of quantum fluid with fractionally charged excitations"
Charles K. Kao	2009	Physics	St. Joseph's College; Woolwich Polytechnic in London in 1957	"for groundbreaking achievements concerning the transmission of light in fibers for optical communication"
Youyou Tu	2015	Physiology or medicine	Peking University	"for her discoveries concerning a novel therapy against Malaria"

(Nobel Media AB, 2018)

aboard. Chen Ning Yang and Tsung-Dao Lee went to the University of Chicago in 1946 and then won the Nobel Prize in physics in 1957. After graduating from Hongkong Augustana College in 1958, Daniel C. Tsui received a PhD from the University of Chicago in 1967 and later won the Nobel Prize in physics in 1998. Charles K. Kao graduated from Woolwich Polytechnic in London in 1957, and he became a Nobel laureate in 2009.

Most of the Nobel laureates have experiences of studying abroad, which means they were not only educated in China. In the science field, Youyou Tu is the unique laureate who won the Nobel Prize in physiology or medicine and was educated in China only. Analyzing these Nobel laureates' education background draws a conclusion that there were no indigenous Chinese scientists who ever won the Nobel Prize in physics and chemistry. The conclusion is very interesting and leads to several thought-provoking questions:

1. What obstructed Chinese scientists from approaching the Nobel Prize?
2. What are the deficiencies in Chinese science education?
3. How can Chinese science education improve to increase Chinese scientists' competitiveness in winning the Noble Prize?

International students from China are defined as lacking the abilities in critical thinking by mass media (Lu & Singh, 2017). No indigenous Chinese scientists ever won the Nobel Prize in physics and chemistry (Nobel Prize AB, 2018), and most Chinese

creative achievements referenced western literature (Lau, Hui & Ng, 2004). Hu, Shen, Lun and Adey (2010) conducted the Scientific Creativity Test among 1,190 British teenagers and 1,087 Chinese teenagers; they found that British teenagers performed better than Chinese teenagers in science experiments, creative imagination, and product design. Wong and Niu (2013) state that the lack of independent inquiry in Chinese schools limited Chinese students' creativity development. Although Chinese students' academic performance is better than their American opponents, their creative thinking ability is surpassed by their Western counterparts. Ma and Rapee (2015) indicate that American students overcame Chinese students in answering open-ended questions and applying creative problem-solving.

Although the Chinese government has emphasized *suzhi jiaoyu* [quality education] since 1999, a 2005 McKinsey Global Institute survey indicated that more than 90% of Chinese workers, for example engineers, are not ideal employees for foreign companies because of their insufficient creative ability and practical skills. Due to the Chinese education bias and the conflicts of education theories between Western and Chinese education, Chinese students show low global competitiveness. It turns out that the quality education did not break the stereotype of Chinese traditional education and failed in cultivating students' personal skills such as individual expression and creative thinking ability (Dello-Iacovo, 2009).

The following part will analyze science education and the utilization of inquiry-based teaching in China. Science education in China has been considered as limiting students' creativity. When utilizing inquiry-based pedagogy, certain preconditions have not been fulfilled.

Limitations of the Science Education in China

Although the reform of science curriculums has been emphasised for a long time, several deficiencies of science learning in Chinese classrooms still hinder the implementation of inquiry-based learning and hence obstruct students' creativity development (Li, 2015). The following parts will list the deficiencies that hinder inquiry-based learning and students' creativity development in Chinese science education. The limitations can be attributed to several factors: the influence of the score-orientated science education in China, the unified content and management, lacking equipment in classrooms and laboratories, teachers and students' traditional beliefs, the authority in classrooms, the isolated academic courses, the size of Chinese classrooms, the inadequateness of teachers' capabilities, the overload of teachers' work, as well as students' internal factors.

The Score-orientated Science Education

Several research studies have shown that when implementing inquiry-based learning in Chinese science classes, the unscientific evaluation system is blamed as the main obstacle (Dai, Gerbino & Daley, 2011). The result of the College Entrance Examination,

which is a standardized test, is the unique criteria determining college placement. The teaching process is significantly affected by standardized examinations in China. The conflicts between the required ability of the college entrance examination and inquiry-based learning pedagogy negatively influence practical implementation of inquiry activities. The curriculum reform emphasized inquiry-based learning as well as students' creativity development, but these qualities have not been included in the final test. As a result, students' exploration is not viewed as necessary. Teachers are confused by what should be measured and how to evaluate students' learning in the process of students' investigations (Wu, 2003). Hui and Lau's (2010) research also showed that students' creativity is not included in the assessment in schools, and at the same time, there are limited strategies for educators to implement creative pedagogy in practice in mainland China. Hong Kong and Taiwan more effectively conduct creative pedagogy in classes; however, their evaluation system does not include creativity testing either (Hui & Lau, 2010).

Chinese teachers have less power in the process of making educational evaluation system decisions. They reported that they are driven by the evaluation system. The College Entrance Exam pressured teachers to focus on students' academic performance instead of creativity development. The purpose of improving students' academic achievement strongly hinders the development of students' creative thinking ability (Zhou, Shen, Wang, Neber & Johji, 2013). Chen and Wei's (2015) research indicates that

lessons in Chinese classrooms are tightly related to examinations, and the content of courses depends on “focal points” in the tests only (Chen & Wei, 2015). Cheng’s (2010) case study shows that some students do not understand the inquiry activities of making assumptions; they believe that the exercise is unrelated to the syllabus and the examinations. Students with negative attitudes towards the inquiry activities reported the feeling of wasting time. They performed worse and saw less improvement in creative thinking ability than other students.

In order to send students to a satisfactory university and gain a “brighter future,” teachers and parents are concerned more with test scores than students’ thinking abilities. Even with the high enthusiasm of inquiry-based teaching pedagogy, teachers are struggling with the practical implementation (Dai, Gerbino & Daley, 2011). The performance-driven education conflicts with inquiry-based learning pedagogy in Chinese science education. The goal of traditional study has been taken as getting high marks, and people take children’s grades as the only evidence of effective learning. Inquiry-based pedagogy mended the views of assessment and emphasizes the process of knowledge gaining. The original views bring passive learning and hence hinder the practice of inquiry-based teaching and further hinder students’ creativity development (Barrow, 2006).

Science education is score-orientated in China. In order to achieve high scores in examinations, Chinese science teachers impart knowledge to students. Chinese students

learn scientific laws by reciting instead of observing and testing (Lu, 2000). Instead of applying the inquiry-based activities in classes, educators gravitate to score-orientated education and follow the “spoon-fed styles of teaching” in classrooms (Huang, 2013, p. 252). Teachers are the center of the class, they teach “what” to students instead of “how”. “What” refers to the existing knowledge such as known scientific laws and formulas. In test-driven classes, teachers directly pass the knowledge to students. “How” refers to the process of scientific knowledge exploration. Inquiry-based learning focuses more on self-exploration activities than restating the known achievements (Wu, 2003).

It is true that memorizing improves students’ academic performance more effectively than inquiry explorations in the exam-driven education system. With the high pressure from the College Entrance Exam, teachers prefer expository teaching to pass the “correct” knowledge and improve students’ academic performance. In teacher-centered classes, students are the audience and passively accept knowledge. A study showed that 90% of the time, students are the listener while teachers are the leader of various class activities in Taiwan. (Cheng, 2004). Educators put more emphasis on passing basic skills and knowledge, and neglect the creativity in both teaching and learning. Chinese students are less engaged in investigative activities and have few chances to present their own thoughts (Niu & Sternberg, 2003). Teaching and learning always serve for test preparation, courses involve what will be examined in standard tests only (Xu, 2008). Although memorizing and recalling improves Chinese students’ academic performance

effectively, their creativity performance was exceeded by their Western counterparts. The reciting and practicing of certain knowledge decreases students' creativity, initiative, and critical thinking ability (Ma & Rapee, 2015). Thus, the rooted traditional passive learning method is difficult to be altered. Conducting inquiry-based learning in Chinese science classes requires the reform of evaluation system, the change of school climate, and effort from administrators (Dai, Gerbino & Daley, 2011).

The Unified Content and Management

The unified textbook and content of science courses limit the flexibility, creativity, and variety of science education in China. Teachers reproduce the textbook content and arrange score-oriented exercises in classes (Cheng, 2004). Even when adopting inquiry-teaching in Chinese classrooms, some teachers neglect students' different pre-knowledge and creativity, and they still follow the specified methods in the textbook in inquiry activities. The undemocratic process of exploration does not benefit students' development of creative thinking (Zhang, Shamsi, Batool, Wan & Yu, 2016).

In addition, basic knowledge and skills cultivation precede creativity training in Chinese education. Fundamental knowledge and skills training begin at childhood; however, creativity training is regarded as secondary to the excellent academic outcomes (Cheng, 2004).

Wang and Xie (2010) reported senior students' eyes seem glazed in a performance. These students played instruments and danced in an orderly way; however, their faces

were dull. The reason was attributed to the overload of stress from academic classes and the excessive unified management in schools. The authors believe that traditional education in China limits students' active mind and kills their creative thinking, critical thinking, and flexible thinking ability.

Limitations of Scientific Experiment

Arranging experiments in the process of exploration is necessary for students' development of creative thinking and inquiry-based learning. However, according to Wei and Li (2017), the practical work in Chinese science classes has been proven not consistent with the inquiry-based learning philosophy. Instead of independent exploration, "recipe-style" experiments are conducting by most Chinese science teachers. Teachers are the leader of the experiments and the sequence of experiments is arranged, students need to follow the instructions directly from teachers and textbooks. In order to prevent students from making mistakes, teachers inform the purpose, method, notes, and procedures of every experiment. Teachers reported that they teach students "procedural knowledge" such as "equivalent principle" and "single variable principle" to make the experiment simpler and easier for students (p. 1784). At the same time, equipment and materials are prepared by teachers as well (Wei & Li, 2017).

The traditional Chinese science limited students' creativity development. The focus of scientific experiments is usually on the equipment manipulation and experimental procedure simulation. The practical work in Chinese science classes is designed to

confirm textbook knowledge, examine the expected result, and test the authenticity of certain theories. Whereas inquiry-based activities require more independent exploration, as well as self and creative observation and discovery. Students are expected to be a “real scientist” in the inquiry explorations, which means they should investigate the uncertain and unknown concepts. They should not be informed of the known process of discovery before getting their own results (Wei & Li, 2017).

Oftentimes, scientific experiments in China are aimed at assisting students to understand and memorize academic knowledge. Teachers present the final result to students in advance and evaluate students by their accurate implementation of getting the same finding. In contrast, in inquiry-based explorations, conclusions are expected to be drawn by students because “real scientists design their own experiments to investigate the unknown world” (Wei & Li, 2017, p. 1784).

Implementing inquiry-based pedagogy demands numerous teaching resources; inquiry activities require related materials and inquiry experiments need preparation (Kim & Tan, 2011). Teachers complained of insufficient apparatus and chemistry teachers are suffering from the lack of various chemical agents (Wei & Li, 2017). Chinese education institutions lack these resources. The absence of teaching tools influences the result of the learning process and limits the application of inquiry pedagogy (Yu, 2015).

Traditional Beliefs

Confucianism is believed as the crucial traditional Chinese philosophy. When comparing East Asian and Westerner ability of creative thinking, East Asians are always regarded as less creative due to the Confucian and collectivistic culture influence (Wong & Niu, 2013). Students who are affected by Confucius culture are less likely to express personal ideas, independent and creativity opinions, and unique perspectives in classes (Cheng, 2004). Confucianism includes the theory of “Zhong Yong” which is an important component of Chinese culture (Zhang, et al., 2016). “Zhong Yong-oriented action model” refers to “a relatively holistic cognitive orientation with less likely extreme perspectives, and compromises, both when encountering opposing ideas and when resolving conflicts” (Yao, Yang, Dong & Wang, 2016, p. 53). Yao, et al.’s (2016) research indicated that people’s “Zhong Yong” thinking is inversely proportional to their creativity and innovations. With a high belief in “Zhong Yong”, people would efface their creativity and do not apply it to innovations; conversely, people who are less dedicated in “Zhong Yong” are more likely to collocate creativity with innovations.

In addition, Chinese believe that comprehending the existing knowledge should occur prior to the development of creativity. Instead of exploring the nature independently, Chinese students are required to acquire the completed scientific laws. At the same time, Chinese believe that creativity can be fostered by study, refining, and enhancing the existing outcomes. However, it only benefits students’ evolutionary

creativity. Students have no opportunity of self-exploration and their minds are limited in the present theories. It is difficult for students to break through the present achievement or develop other types of creativity. The traditional approach of creativity cultivation contributes to Chinese students' high academic performance but low creative ability when compared to Westerners (Wong & Niu, 2013).

Moreover, the traditional belief affects the nature of teaching and learning; teachers' beliefs influence the application of inquiry-based teaching and the practice of inquiry activities in classrooms (Roehrig, Kruse & Kern, 2007). Some teachers show no tolerance for incorrect but creative answers. Instead of letting students find out the truth, teachers criticized the "misconceptions" immediately in class (Cheng, 2010). Students who are influenced by the traditional culture always attempt to reply with "correct" or "acceptable" answers in classes. They believe that creative answers and innovations are not expected in traditional classrooms in China (Ho & Ho, 2008). In the hypothesis making exercise, many students still sought the expected and correct answers. They frequently asked teachers if their answers are appropriate in the process of the inquiry activity. The purpose of integrating open-ended questions was to emphasize the creative thinking, in fact, students were confused and uncomfortable with the "freedom" (Cheng, 2010).

When comparing Chinese teachers concerns with American teachers, Dai, et al. (2011) found that many Chinese teachers query students' knowledge and abilities to

conduct inquiry activities on their own. They are concerned with students' confusion or fault in the process of independent exploration. However, 39 Americans in the survey showed no worries of the same problem. Inquiry-based learning requires teachers to encourage students' curiosity and guide students' operation during the inquiry activities. It allows students to make mistakes, instead of directly correcting students; teachers should inspire students and let them find out the answer by themselves (Chong, Chong, Shahrill & Abdullah, 2017). Nevertheless, in the practice of Chinese science classes, most teachers lead every experiment. They ask students to follow their instruction step by step in case of making any mistakes. The belief of avoiding students from "making detours" conflicts with the idea of independent learning in inquiry-based activities. Teachers' "thoughtful instructions" obstruct the implementation of inquiry-based learning, the avoidance of letting students making mistakes limits the opportunity for creativity releases. Students afraid of getting incorrect results lack confidence of making attempts in the process of exploration (Dai, et al., 2011). Thus, the deep-rooted traditional Chinese philosophy obstructs teachers' creative teaching and students' scientific innovations.

The Authority in the Classroom

The authority of the teacher also combines with the traditional culture in China. Confucianism praises filial piety and loyalty, young people are required to respect elders, the subordinate should comply with superior, and students should listen to teachers and

respect present knowledge. Meanwhile, Confucianism forbids the behaviour of challenging authority and makes it a moral rule (Ho & Ho, 2008). A respect for authority is part of traditional Confucius virtues. Students should obey and follow educators' instructions in school. This compliance limits students from expressing alternative and creative ideas (Ma & Rapee, 2015). Besides the authority of teachers, textbooks, which refers to present knowledge, are the only reference in classes. Riley (2013) observed traditional teacher-centered classes in China and reported that class activities were book-oriented. There were little inquiry-based activities and explorations to release students' creativity in traditional Chinese classrooms. As a result, the respect for authority negatively influenced students' creativity development.

Due to this traditional belief, teachers naturally become the center of the classroom in inquiry activities in classrooms in China. Instead of guiding the exploration, educators directly pass the knowledge to students. Teachers explain the process of solving problems, provide definitions, and initiate "truth" to pupils (Sun, 2015). In addition, the knowledge in Chinese classrooms are "absolute, defined by an authority as right or wrong and expects expository teaching with the focus on content and reproduction of material in their assignments", and students fear raising doubts or their perspectives. (Durkin, 2008, p. 18).

Thus, the Confucian-heritage education encourages compliance and respect for educators and present knowledge, hinders the practice of inquiry-based teaching in

China, and has negative influence on students' critical and creative thinking (Ho & Ho, 2008).

Isolated Academic Courses

In terms of preparing students' creativity for the unpredictable future, the content of Chinese science courses should not focus solely on academic understanding. As the content of courses is shaped by the interaction between teachers and curriculum (Remillard, 2005), educators play an important role in the process of transforming curriculum theories into real life (Remillard, Herbel-Eisenmann & Lloyd, 2009). However, in several Chinese classrooms, instead of applying scientific laws in real life, Chinese students were required to apply what they learned and practiced in school examinations only (Qu & Li, 2005). Therefore, students master scientific laws as isolated academic knowledge. When facing real-life problem beyond their knowledge, without the experience of solving real-world tasks, their ability of getting solutions and creative thinking is uncertain.

The Size of Chinese Classrooms

Class size in Chinese classrooms hinders the development of inquiry-based learning and creative learning. There are approximately 60-70 students in a class, most of the students are not fully engaged in the class, and the chance for students to raise their own ideas is limited. It is difficult for teachers to guide students through the process of exploration and elaboration. Oftentimes, teachers have to unify the methods of

experiments to better control the class (Chen & Wei, 2015). Teachers spend time on class management. They have to be the center of the classroom and conduct punishment to better control the class. Several collaborative inquiry-based experiments are impracticable due to the need for a well-organized classroom. Inquiry activities, exploration, and experiments are difficult to conduct because of the emphasis on classroom discipline in a large class (Cheng, 2004). Thus, with the large class size and the limited class time, although students' curiosity has been developed, it is difficult to do deep inquiry and explorations, and students' creativity is negatively affected (Wu, 2003).

Besides, inquiry-based activities only benefit students with correct pre-knowledge and students who can operate experiment effectively and cooperatively. In practice, half of the pupils cannot follow the activities, they cannot accomplish projects well and would be negative in class. Students who enjoy the inquiry classes will learn positively, while others will learn ineffectively (Li, 2015). Therefore, students in a large class have fewer opportunities for the improvement of creative learning.

The Inadequateness of Teachers' Capabilities

Brown (2009) reported that the quality of curriculums is depended on teacher's pedagogy, material use, as well as their abilities. The result of Chen and Wei's (2015) study showed that teacher's pedagogical content knowledge decides the adaptations of class materials. Inquiry-based teaching is more difficult than traditional teaching because it demands teachers to have a set of capabilities such as high level of conception to

answer questions, the ability of management and organization to control the classroom. An educators' capacity plays an important role in inquiry-based learning implementation. Inquiry-based learning is only an idealistic pedagogy if there is no professional training (Dai, Gerbino & Daley, 2011). Teachers reported that student-centered pedagogy is too abstract to implement in practice. The training for student-centered pedagogy is insufficient for comprehension. Teachers believe that they are informed and forced to conduct the new model when in fact, "they are left to try it out on their own" (Lai, 2010, p. 621).

Most teachers did not experience inquiry activities in their schooling lives. Even fewer teachers have mastered the skill of inquiry activity implementation. Educators who get used to book-oriented classes find many difficulties in the practical inquiry classes. Inquiry activities require a teachers' ability in flexibility. Oftentimes, the contents need to be adjusted to apply to students' exploration. However, because traditional science teachers rely on the class outline and the schedule, they lack the ability of adjustment and integration (Wu, 2003). Many teachers lack the confidence to put inquiry-based pedagogy in practice (Kim & Tan, 2013). At the same time, several studies have shown that teacher training programs did not satisfy teacher's need of breaking the stereotypes of traditional lectures (Xue & Chen, 2012). Science in the undergraduate training programs was divided into physics, chemistry, biology, and geography (Hao, 2014) until the unification of science education in 2001. Meanwhile, training mainly focused on

traditional lecturing instead of creativity teaching. Trainees reported training did not benefit their scientific literacy and the development of their teaching pedagogies which refers to the utilization of inquiry-based teaching in practical classes (Zhang, et al., 2016).

The Overload of Teachers' Work

Mr. En, a Chinese chemistry teacher, reported that he did not follow the inquiry-based teaching pedagogy because of the time constraint. By the same token, instead of arranging inquiry activities, Mr. Fang demonstrated the experiment by himself (Chen & Wei, 2015).

In addition, many teachers reported that inquiry-based activities are time-consuming. In order to stay on time, teachers shrink the inquiry activities and give less time for students than needed (Cheng, 2010). Schooling and class time are limited, and students are not able to complete inquiry experiments in a short period of time. Guaranteeing the teaching schedule and arranging scientific inquiries in classes is challenging to most teachers (Wei & Li, 2017). Furthermore, many educators complain about the lack of time for preparing inquiry and teaching materials. They are too busy to design creative teaching activities, and to reflect the process of teaching after class. Some educators overlooked the importance of introspection, and they failed to collect data from each class to summarize the most appropriate way of inquiry-based teaching in China (Li, 2015).

The Factor of Students

There are a set of problems for Students in Chinese science class in inquiry based pedagogy. Prior knowledge is the first factor that should be focused on. According to Pintrich, Marx, and Boyle (1993), students with low prior knowledge would seek non-specific closure which would obstruct the exploration process in inquiry activity. Besides, incorrect prior knowledge would hinder exploration as well. For example, students insisted that heat is from a sweater, glove or a scarf and refused to give up the idea even after several experiments presented opposite result (Bybee, Carlson-Powell & Trowbridge, 2008). Thus, when students attempt to engage in and explore inquire-based activities, their low and unreliable previous knowledge would lead to bias and confusion, so the learning process is not as smooth as expected.

Another challenge is young adolescent's capability of concentration and elaboration. It is difficult for kids to focus on one task for a long time, and unrelated topics can be mentioned during the discussion. Inquiry-based pedagogy requires children to engage in classroom activities, to explore, explain, and elaborate the topic. Although pupils may enjoy doing experiments, the following elaboration and evaluation would be beyond most children's capabilities (Teaching Inquiry Science Activities). A creativity project showed that some students raised humorous answers, while teachers were expecting serious and meaningful responses (Cheng, 2010). The distractions can delay the inquiry activities and lead the expected creative answers in the wrong direction.

Moreover, traditional teaching pedagogy in China ignores the importance of cultivating students' critical thinking. Students' dissatisfaction of existing knowledge is hard to trigger because they always rely on authoritative theories instead of questioning and testing the information. Besides, teachers are the center of the Chinese traditional classroom, so students only pay attention to the teacher's speech. Some students are unwilling to speak because they are afraid of making mistakes. Thus, in terms of inquiry-based learning, students may be too shy to join in the class discussion and unwilling to report their results (Li, 2015).

CHAPTER III: CONCLUSION AND RECOMENDATIONS

Conclusion

Literature has provided evidence of the curriculum reform expectation and its failure in gaining expected achievements. It is believed that inquiry-based learning can significantly benefits students' learning. However, the "hierarchy of subjects", "stereotypes", "spoon feeding", "killing creativity", and "knowledge acquisition" in public education has been criticized as obstacles in the process of nurturing children's creativity in Chinese education. Base on the literature review, the limitations in Chinese science education can be attributed to the influence of the score-orientated science education in China, the unified content and management, lacking equipment in classrooms and laboratories, teachers and students' traditional beliefs, teachers' authority in classroom, the isolated academic courses, the size of Chinese classrooms, the inadequateness of teachers' capabilities, the overload of teachers' work, as well as students'' internal deficiencies.

Research Questions

Question 1: Has Chinese science education gain the expected achievement by conducting inquiry-based learning?

Chinese government announced the curriculum reform in 1999. Although the government has expressly presented that inquiry is the major pedagogy in science education, Chinese science education did not gain the expected achievement. Several

deficiencies still limit the utilization of inquiry-based learning and students' creativity development.

Question 2: What are the limitations that hinder inquiry-based learning and students' creativity development in Chinese science education?

Score-orientated science education in China has been viewed as the largest limitation. The curriculum reform emphasized inquiry-based learning as well as students' creativity development. However, the evaluation system still remains. Educators are driven by the college entrance examination. They hope to immediately improve students' scores which conflicts with time-consuming student self-exploration. Teachers are forced to conduct new models in classes with insufficient guidance. The inaccurate implementation of inquiry-based learning is not benefiting students' learning and is misleading students' creativity development.

The reliance on unified textbooks limits the flexibility, creativity, and variety of science education in China. The "recipe-style" book of experiments does not meet with the expectation of students' self-exploration and creativity development. Students are not "real scientists" as required by the inquiry-based learning pedagogy due to the inaccurate purpose of science experiments and the lack of materials. In addition, the deep-rooted traditional Chinese philosophy brings Confucian-heritage education to Chinese science education. Traditional beliefs such as the theory of "Zhong Yong" and the authority structure in classrooms are difficult to break.

Chinese science courses are separate from real-life problems. Students master scientific laws as isolated academic knowledge. With the large class size, teachers find it difficult to arrange, control, and extend the inquiry activities. Teachers are challenged by altering their role, arranging and organizing the class, and the lacking in training, practice and time. Many teachers lack the ability, knowledge, and confidence to implement inquiry explorations. Educators, with pressure from the class schedule, have failed in developing class inquiries as well. Furthermore, students' internal factors, such as the incorrect pre-knowledge, unequal capabilities, and the fear of making mistakes, have negatively influenced inquiry activity conduction.

Therefore, several difficulties in evaluation policy, culture background, teachers' and students' ability, and various factors have been discussed as obstructing the implementation of inquiry-based learning in Chinese science classes, and limit Chinese students' creativity development.

Question 3: What strategies can be used for Chinese science education to effectively improve inquiry-based learning and students' capability of creative thinking?

Teachers should allow students to be the center of the classroom and arrange authentic experiments in science classes. Sharing ideas requires teachers to communicate and solve each other's difficulties in the process of practical implementation. Educators' comprehension of inquiry-based learning pedagogy and their transformation of traditional

belief and attitude would benefit the improvement of inquiry-based learning and students' creativity development in Chinese science classes.

It is time for policy makers and administrators to reconsider the evaluation system in China. The traditional evaluation policy of the standardized tests needs to be improved to benefit the implementation of inquiry-based learning. The funding should be increased to improve equipment and materials for scientific experiments. Inquiry-based learning will be more effective with adequate support and will promote student creative thinking ability in science learning.

Recommendations

Cultivating students' creativity is considered the key factor in preparing young generation for the unpredictable future, and science education plays the most important role in the process of developing students creative thinking skills. The following parts discuss various recommendations in science education to effectively improve inquiry-based learning in Chinese science classes and students' capability of creative thinking.

Building Student-centered Classroom

Teachers' attitudes influence students' performance in classes. In terms of cultivating students' creativity, teachers should be open-minded and encourage students to promote creative ideas. Teacher ethos is an determining factor for authority in the classroom. Students are more likely to express their own perspectives when educators build a humanistic and flexible environment in classes. During the Class, educators must create

opportunities and environment for students' innovation. Inquiry-based teaching as a creativity promoting strategy requires educators to allow students to be the center and solve puzzles themselves. In order to smooth the discussion and engagement in inquiry activities, teachers can arrange students into several groups. At first, teachers should excite children's curiosity and interest by questioning or creating conflicts. When pupils begin to explore the topic, teachers should encourage them, pay attention to their process, give advice instead of answering questions directly, and carefully offer some tips and guidance to kids in earlier grades. Meanwhile, students should keep thinking critically and implement the task cooperatively. After the experiment or observation, instead of offering definition directly, teachers should encourage children to offer appropriate explanations with their own experience and words. It is the time for students to combine new knowledge with their conceptions. At last, isolated evaluations should not be applied anymore. Open-ended questions would prove that students have altered their way of thinking, accepted the inquiry method, learned new knowledge, and develop creative thinking during the inquiry activities.

Connecting Academic Knowledge with Authentic Examples

In terms of the content of science classes in China, connecting academic class with the real-world benefits inquiry-based learning and students' creativity. Promoting the concern of real problems in society increases students' responsibilities and capabilities in problem-solving. Associating scientific experiments with the concern of real problems,

such as resources insufficiency and diseases treatments, closes the gap from formalist class experiment to real scientific inquiries. “Learning by doing” benefits students’ academic learning. It is believed that authentic pedagogy improves students’ interests, engagement, and motivation in inquiry-based activities. For example, dynamic in physics is an abstract concept, and many students struggle with the force analysis. Why is a football only influenced by gravity (g) and friction (f) after the moment of kicking? Why does the football keep going forward but the force from human’s behaviour does not show in the force analysis? This concept can be confusing when teachers explain it using only abstract theories only. However, the authentic pedagogy can respond to the dynamic question. A real outdoor experiment can perfectly indicate that the forces of a human’s kick will no longer influence the football after kicking. As we all know, forces are mutual. However, when a student kicks a football in practice, he or she can only feel the reactive force at the moment of kicking. The student cannot feel the force of the football while it is moving forward. By the same token, there is no force of kicking on the football as long as it gets apart from the student’s foot. This authentic experiment explains the questions well, and it is a wonderful pedagogy for science teachers to inspire students in making connections between academic lessons and real life.

Besides, educators should integrate knowledge with-real world problems such as famine, population growth, resource and energy scarcity, and environmental pollution in classes. Educators should encourage students to investigate causes and harms of several

disasters, and further encourage students to give full play to their creativity in exploring the solutions. In addition, inquiry-based activities should reflect the prospect of current science and technologies such as the basic knowledge of cloning, nanotechnology, genetic engineering, biological materials, green chemistry, and renewable energy. Students would benefit from the basic knowledge of science and the ability of creative thinking in future real-life task explorations.

Sharing Ideas

The problem of lacking knowledge and time can be solved by sharing ideas, in other words, it asks teachers to work collaboratively. Teachers can share lesson plans, schedules, reflections and suggestions on a certain website which is available for the group. The website allows everyone to express their own or new ideas, it is a platform where teachers can get more information, enhances teaching skills, and allows teachers to learn from others' experiences and exchange creative opinions. Thus, educators will work more effectively to develop inquiry teaching in classes.

Improving Assessment and Evaluation

Research studies showed the failing of inquiry-based teaching was affected by the standardized test in China. The process of assessment and evaluation affects students learning habits; and the score-oriented science education significantly hindered students' creative thinking development. Since teacher's management of students seriously damaged students' intellectual development, educators should encourage diversity and

creative behaviours in schools. It is time to improve the assessment in classes, break the traditional evaluation policy of the standardized tests in China, and promote more creativity evaluation in science learning.

Increasing Resources

When operating inquiry-based experiments, lacking equipment and materials in the laboratory limits the observation and exploration process in inquiry-based learning. With the large class size, government funding is insufficient and unequal in many schools. It is essential for the government to support schools by increasing public funding.

At the same time, schools should take full advantage of investment to integrate learning materials and equipment. In addition, more funding should be utilized in educators' training. Professional and authoritative direction would benefit teachers' transformation from traditional beliefs to inquiry-based teaching pedagogy. As a result, teachers will be supported by learning resources and students will be engaged in diversity inquiry activities effectively. The adequate resources provide students more opportunities to test their hypothesis and integrate creativity in the process of exploration.

Future Research

Since test-driven education is the most serious obstacle, future research can focus more on the improvement of the evaluation system in China. More research can be conducted to explore a reasonable and appropriate evaluation system along with the inquiry-based learning pedagogy in Chinese classrooms. The college entrance

examination is held once a year and it is the only reference for university enrollment in China. It would be useful to research the frequency of the college entrance examination as compared with various western countries. Researchers can analyze whether the evaluation system should be divided into several parts and conducted at different times of the year as well. The curriculum reform will become more successful with the improvement of the evaluation system in China.

Moreover, researchers can give more recommendations on decreasing the influence of Chinese traditional beliefs on students' creativity development. Although the deep-rooted Confucianism cannot be eliminated, professional training of inquiry-based learning will benefit teachers' practical implementations. Future studies can focus on the strategies of improving Chinese teachers' understanding and inquiry-based learning skills. At the same time, researchers can investigate factors that influence students' traditional beliefs and give suggestions to improve students' performance in inquiry activities.

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